

ANALYSES OF BURROWING OWL POPULATIONS IN NEW MEXICO

PATRICIA C. ARROWOOD¹

*Department of Fishery and Wildlife Sciences and U.S.G.S., New Mexico Cooperative Fish and Wildlife Research Unit,
Box 30003, MSC 4901, New Mexico State University, Las Cruces, NM 88003 U.S.A.*

CAROL A. FINLEY

*Department of Fishery and Wildlife Sciences and U.S.G.S., New Mexico Cooperative Fish and Wildlife Research Unit,
Box 30003, MSC 4901, New Mexico State University, Las Cruces, NM 88003 U.S.A.*

BRUCE C. THOMPSON

*Department of Fishery and Wildlife Sciences and U.S.G.S., New Mexico Cooperative Fish and Wildlife Research Unit,
Box 30003, MSC 4901, New Mexico State University, Las Cruces, NM 88003 U.S.A.*

ABSTRACT.—Populations of western Burrowing Owls (*Athene cunicularia hypugaea*) in New Mexico were assessed using a variety of approaches: 1) multi-year studies at three specific sites; 2) a single-season survey of prairie dog (*Cynomys* spp.) colonies in five northeastern counties; 3) a questionnaire to state and federal agencies, private organizations, and biologists throughout the state; 4) analysis of North American Breeding Bird Survey results from 1968–2000; 5) owl counts at prairie dog re-establishment sites; and 6) incidental reports and other sightings. Owl populations in some areas were reportedly stable or increasing, but were decreasing in other areas. Factors most often reported to be associated with stable or increasing populations were food availability, suitable habitat (including the presence of prairie dogs), and increased precipitation. Declining populations appeared to suffer from loss of suitable nesting habitat, caused either by disappearance of prairie dog colonies or by urban sprawl into arid lands and farmland. Declining populations also suffered from high predation, persecution, or disturbance by rock squirrels (*Spermophilus variegatus*). In some cases, the causes for declines were unknown. Overall, the data suggest moderate concern for Burrowing Owl populations in New Mexico.

KEY WORDS: *Burrowing Owl*; *Athene cunicularia hypugaea*; *population trend*; *agency survey*; *prairie dog*; *Cynomys spp.*; New Mexico.

Analisis de las poblaciones del Búho Cavador en nuevo México

RESUMEN.—Las poblaciones de los Búhos Cavadores Occidentales (*Athene cunicularia hypugaea*) en Nuevo México fueron evaluadas utilizando una variedad de métodos: 1) Estudios de múltiples años en tres sitios específicos; 2) Un estudio de una sola estación de las colonias de perros de la pradera (*Cynomys* spp.) en cinco condados nororientales; 3) Un cuestionario para agencias estatales y federales, organizaciones privadas, y biólogos a lo largo del estado; 4) Analisis de los resultados del Monitoreo Americano de Reproduccion desde 1968–2000; 5) Conteo de búhos en sitios de re-establecimiento de perros de la pradera; y 6) Reportes incidentales y otros avistamientos. Las poblaciones de búhos en algunas áreas fueron reportadas como estables o en incremento, pero estaban decreciendo en otros lugares. A menudo los factores reportados mas asociados con poblaciones estables o en aumento fueron la disponibilidad de comida, hábitat adecuado (que incluye la presencia de perros de la pradera), y el incremento de la precipitación. Las poblaciones en declive parecían sufrir de perdida del hábitat de anidación adecuado, causado ya sea por la desaparición de las colonias de perros de la pradera o por la expansión urbana dentro de tierras áridas y de cultivo. Las poblaciones declinantes sufrían además de alta depredación, persecución, o perturbación por parte de ardillas de roca (*Spermophilus variegatus*). En algunos casos, las causas del decline fueron desconocidos. En conjunto, los datos sugieren una preocupación moderada para las poblaciones del Búho Cavador en Nuevo México.

[Traducción de Victor Vanegas y César Márquez]

¹ E-mail address: parrowoo@nmsu.edu

The western Burrowing Owl (*Athene cunicularia hypugaea*) is referred to as a 'high responsibility species' by U.S. National Partners in Flight. That classification is based on trends from North American Breeding Bird Survey data and the percent of the species' breeding range within western physiographic areas. In this paper, we provide information about population trends at three locations, report population numbers from a single-season survey of five counties in northeastern New Mexico, summarize responses to a questionnaire we sent to various agencies throughout the state, summarize Burrowing Owl data from the North American Breeding Bird Survey (1968–2000), and report data from other sites, including three sites where prairie dog colonies have been re-established.

Physiography of New Mexico. We used physiographic areas to evaluate the state with respect to potential for Burrowing Owls. New Mexico is physically and biotically diverse, consisting of deserts, plateaus, mountain ranges up to 4011 m high (some with extensive forests), rivers, grasslands, and farmland. The lowest elevation is 866 m, in the southeastern part of the state. The state has a total area of 311 478 km². Tectogenic events have affected primarily the western two-thirds of the state, resulting in mountains, mesas, plateaus, valleys, and basins. The eastern one-third of the state is a relatively level plain (Findley et al. 1975). Despite this physical diversity, the state can still be classified as mostly grassland (Findley et al. 1975).

Ecozones known to have Burrowing Owls or to have the potential for Burrowing Owls are found throughout the state (Fig. 1). The ecozones were identified from Dick-Peddie's (1993) classification of 16 ecological zones in New Mexico. The 10 ecological zones identified as known or potential owl sites comprise 74.9% (233 226 km²) of the state's area; the six unlikely owl ecological zones comprise 25.1% (78 252 km²) of the state's area (Dick-Peddie 1993 cited in Thompson et al. 1996).

In these known/potential ecozones, the owls may use or enlarge the burrows of various solitary or colonial mammals, including prairie dogs (*Cynomys ludovicianus*, *Cynomys gunnisoni*), kangaroo rats (*Dipodomys ordii*, *D. spectabilis*), hares and rabbits (*Lepus californicus*, *Sylvilagus audubonii*, *S. floridanus*), squirrels and chipmunks (*Spermophilus variegatus*, *S. lateralis*, *S. tridecemlineatus*, *S. spilosoma*, *S. mexicanus*, *Ammospermophilus leucurus*, *Eutamias quadrivittatus*), pocket gophers (*Thomomys talpoides*,

T. bottae, *Geomys bursarius*, *Pappogeomys castanops*), skunks (*Spilogale gracilis*, *Mephitis mephitis*, *Conepatus mesoleucus*), badgers (*Taxidea taxus*), and possibly rats (*Sigmodon hispidus*, *Neotoma micropus*; classification by Findley et al. 1975). Miscellaneous burrow sites that are more unusual include pipes laying on the ground, drainage pipes in rock walls, crevices under concrete walks or buildings, and inside interstate highway interchanges (P. Arrowood, C. Blood, C. Finley pers. observ.). In towns and cities, Burrowing Owls are found in parks, lawns, campuses, the upper edges of drainage arroyos, and the banks of irrigation canals (P. Arrowood pers. observ.). Rarely, the owls dig their own burrows by scratching with their feet in soft dirt (pers. observ.). It is well known that Burrowing Owls prefer burrows that are in more open habitat (Haug et al. 1993). Thus, some of the potential habitat shown in New Mexico (Fig. 1) may not be used because of dense stands of mesquite (*Prosopis glandulosa*, *P. pubescens*), creosote bush (*Larrea tridentata*) or other tall vegetation; however, banks and other open areas that provide acceptable nesting sites sometimes occur within such habitats.

STUDY AREAS AND METHODS

Sites Studied for Multiple Years. The most intensively surveyed or studied areas in New Mexico include the New Mexico State University campus (NMSU) in Las Cruces (Botelho 1996, Botelho and Arrowood 1996, 1998), Holloman Air Force Base near the city of Alamogordo (K. Johnson, L. Delay, P. Mehlhop, K. Score unpubl. data, Hawks Aloft Inc. unpubl. data), and Kirtland Air Force Base (Hawks Aloft Inc. unpubl. data) in Albuquerque (Fig. 1).

Burrowing Owl research began at NMSU in 1993 (Botelho 1996, Botelho and Arrowood 1996, 1998) and has continued to the present. Adult Burrowing Owls and their offspring were found while driving campus streets and walking through the football stadium and athletic fields, the old landfill, a flood control dam and nearby desert vegetation, and irrigated pastures two to three times/week. Owls were counted on the 364 ha campus in every year, except 1996, and attempts were made to band every bird. All burrows that were used, even temporarily, were marked with special posts. We and the NMSU Physical Plant Department maintained maps of all marked burrows. Burrows that were to be affected by construction were identified well in advance, and replacement artificial burrows were installed as close to the original burrows as possible.

Holloman Air Force Base is located in the Tularosa Basin near Alamogordo (Fig. 1). To determine Burrowing Owl numbers, K. Johnson, L. Delay, P. Mehlhop, K. Score in 1996–97 (unpubl. data) and Hawks Aloft Inc. in 2000 (unpubl. data) did 15 m transects through two general areas (airway taxiways and a high-speed land test track) where Burrowing Owls had occurred historically.

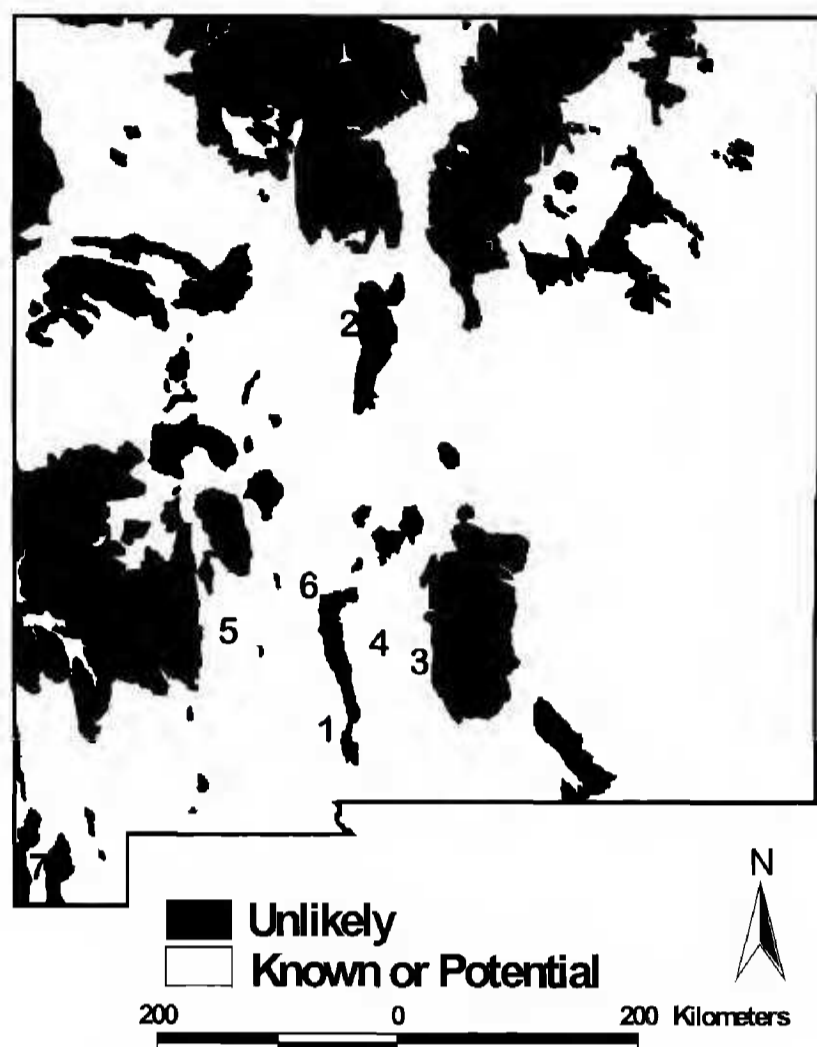


Figure 1. Map of New Mexico showing known or potential ecozones (Dick-Peddie 1993) with Burrowing Owls, including Chihuahuan desert scrub, closed basin scrub, desert grassland, Great Basin desert scrub, juniper savanna, lava beds, plains-mesa grassland, plains-mesa sand scrub, sand dunes, urban and farmland. Ecozones unlikely to support owls include alpine tundra, coniferous and mixed woodland, montane coniferous forest, montane grassland, montane scrub, and subalpine coniferous forest. Numbers indicate the locations of the following sites: 1—New Mexico State University, 2—Kirtland Air Force Base, 3—Holloman Air Force Base, 4—White Sands Missile Range, 5—Ladder Ranch, 6—Armendaris Ranch, 7—Gray Ranch.

Kirtland Air Force Base in Albuquerque (Fig. 1) has the largest population of Burrowing Owls studied in New Mexico (C. Finley and N. Cox pers. observ.). The number and location of all owls has been monitored each year since 1998 by Hawks Aloft Inc. and the base biologist. During daily surveys (5 days/week, early morning or early evening) all areas known to have had owls were driven by car from late February–May. Large areas could be seen from the vehicle so no transects were done.

Single-Season Survey of Five Northeastern Counties. The Rocky Mountain Bird Observatory (formerly the Colorado Bird Observatory) is a non-profit conservation organization whose program, Prairie Partners, is an effort to assess the status of avian prairie-linked species in Wyoming, Montana, Colorado, and New Mexico. The observatory employed C. Finley to survey systematically for

Burrowing Owls at prairie dog colonies in five northeastern New Mexico counties (Union, Colfax, Harding, Quay, and San Miguel) in early summer 1998. To locate prairie dog colonies, Finley drove state and county roads. When a colony was located, the landowner was contacted for permission to visit the colony to search for Burrowing Owls (see VerCauteren et al. 2001 for methodology). No distinction was made between adults and young.

Owl Survey by Questionnaire. In 1998, a questionnaire was e-mailed to 15 state and federal agencies, private organizations, and biologists throughout the state. We asked the following: 1) Can you briefly describe the geographic area in which you have populations of Burrowing Owls? 2) In that area, are the populations urban, rural, or both? 3) What is the estimated number of owls in the area? 4) Have Burrowing Owl numbers remained stable, increased, or decreased during the last five years in the area you described? 5) What do you believe are the factors responsible for any change you have noted? Most people who responded to the survey were also contacted by telephone to review their responses.

North American Breeding Bird Survey. Data on Burrowing Owl numbers were gathered from the BBS routes in New Mexico from 1968–2000 and analyzed for trends (Sauer et al. 2001).

Burrowing Owls at Prairie Dog Re-establishment Sites. At the Ladder Ranch (Fig. 1), ca. 6 km west of the city of Truth or Consequences, a program began in 1995 to re-establish black-tailed prairie dogs (*Cynomys ludovicianus*). Prairie dogs were re-established at three locations. At the Armendaris Ranch, ca. 25 km northeast of Truth or Consequences, six colonies of black-tailed prairie dogs have also been re-established. In addition, black-tailed prairie dogs have been re-established in parts of the former Gray Ranch (1300 km²) in the Animas Mountain region in the southwestern “boot heel” of New Mexico, now managed by the Malpai Borderlands Group.

RESULTS

Sites Studied for Multiple Years. **New Mexico State University:** Despite the maintenance of a near constant number of burrows, the population of breeding Burrowing Owls varied considerably over the course of our study (Table 1). In particular, large declines in the number of nesting pairs occurred between 1995–97 and between 1998–99. We do not know what caused these declines, but we outline here at least two of the potential factors.

In February 1998, an old landfill with many crevices and burrows dug by squirrels (Botelho 1996, Botelho and Arrowood 1998) was filled so that most potential owl nesting sites were eliminated. Because the landfill had contained 24 pairs in 1 yr (Botelho and Arrowood 1998), the university installed 24 artificial burrows nearby (at sites determined by P. Arrowood) to replace burrows lost in the landfill. Noticeable drops in the number of

Table 1. Numbers of pairs and reproductive success of Burrowing Owls on the New Mexico State University campus, Las Cruces.

YEAR	NO. BREEDING PAIRS	NO. NESTLINGS	MEAN NO. NESTLINGS/PAIR
1993 ^a	24	40	1.67
1994 ^a	19	65	3.42
1995 ^a	30	42	1.40
1996	—	—	—
1997	14	48	3.43
1998 ^b	16	24	1.50
1999 ^b	4	18	4.50
2000	9	31	3.44

^a Years from Botelho (1996).

^b Years of increased sightings of rock squirrels.

breeding pairs occurred 1–2 yr before and 1 yr after the loss of the landfill burrows.

The Burrowing Owl population drop between 1998–99 also coincided with increased sightings of rock squirrels (*Spermophilus variegatus*) across campus (Table 1). Rock squirrels dig multiple burrows, some of which are used by the owls, but we suspect that these rather large (600–800 g) squirrels sometimes displace owls from burrows and eat owl eggs. In one brief experiment, Finley installed an artificial burrow in a rock squirrel colony and put pigeon eggs in the burrow chamber. A rock squirrel entered the burrow and emerged with an egg in its mouth. Although there were no owls there to defend the burrow, this experiment did document that squirrels eat eggs.

The squirrels are usually in hibernation when migrating male Burrowing Owls arrive and choose a burrow, but female owls arrive later and may therefore encounter active squirrels upon arrival (pers. observ.). However, few owl pairs have arrived on campus and then left, so the presence of rock squirrels does not directly explain the low number of owls that arrived on campus after 1998.

The number of young produced also varied among years (Table 1). In three of the seven study years, the mean number of nestlings produced per nesting pair was <2, and in the four remaining years, the mean was >3. Interestingly, whenever the mean number of nestlings per pair was <2, the population decreased in the following year, and whenever the mean was >3, the population increased in the following year.

Holloman Air Force Base: The number of pairs was 18 in 1996 and 19 in 1997 (K. Johnson, L.

Table 2. Numbers of pairs and reproductive success of Burrowing Owls on Kirtland Air Force Base, Albuquerque, New Mexico.

YEAR	NO. BREEDING PAIRS	NO. PAIRS WITH FLEDGLINGS (%)	TOTAL NO. FLEDGLINGS	MEAN NO. FLEDGLINGS PER BREEDING PAIR
1998	52	44 (85)	137	2.6
1999	48	39 (81)	125	2.6
2000	37	23 (62)	90	2.4

Delay, P. Mehlhop, and K. Score unpubl. data). The base biologist (H. Reiser pers. comm.) estimated that there was also this approximate number in 1998. A survey of all historically-occupied burrows found only two pairs and five young in 2000 (Hawks Aloft Inc. unpubl. data), a population decline of 89% since 1997. The decline was attributed to a loss of burrows. Some of the burrows available to the owls in 1996–97 had been created when pipelines were dug in the unique gypsum/clay soils, resulting in depressions and cavities. Some of these cavities were created and maintained by rock squirrels, badgers, and foxes. However, during the 2000 surveys, no signs of fresh badger diggings were observed and only a few rock squirrels were seen. Most of the burrows appeared to have collapsed internally.

Kirtland Air Force Base: The owls are associated with colonies of Gunnison's prairie dogs (*Cynomys gunnisoni*), which occupy 441 ha on the base. Since 1998 (Table 2), numbers of breeding pairs, percent of pairs with fledglings, and total fledglings have all decreased; whereas, the number of fledglings per breeding pair has remained nearly constant. Abandonment of burrows (probably some containing clutches), sometimes apparently due to human disturbance, is one factor that led to the decline in percent of breeding pairs fledging young, but it does not account for the decline in the number of owls arriving each spring.

Single-Season Survey of Five Northeastern Counties. Finley saw Burrowing Owls at 36 of the 49 (73%) prairie dog colonies surveyed, for a total of 385 owls. Owls may have been present at other colonies but were not detected if they were inside burrows. The 385 owls recorded is much greater than any North American Breeding Bird Survey (BBS) single-year total for northeastern counties, or even for the state as a whole (see below). Of

Table 3. Summary of responses to a 1998 questionnaire about Burrowing Owl populations in New Mexico.

RESPONDENT AREA	COUNTY	DESCRIPTION	YEAR	NO. OWLS	STATUS ^a	FACTOR ^b
New Mexico State University	Dona Ana	Urban	1998	32	Un	Un
Las Cruces	Dona Ana	Urban	2000	68	Un	Un
White Sands Missile Range	Dona Ana	Rural	1997	1	Un	Un
			1998	4	Un	Un
Bureau of Land Management	Otero	Rural	1998	2	Un	Un
	7 counties	Both	1998	Un	S/I	H, F, OP, PC
Ladder Ranch	Sierra	Rural	1998	14	I	H, F
Armendaris Ranch	Sierra	Rural	2000	48	Un	Un
Private Organization	Bernalillo	Urban	1998	Un	D	LH
Private Organization	Santa Fe	Both	1998	Un	D	LH
Audubon Society	San Juan	Both	1998	Un	D	LH
Bureau of Land Management	Eddy	Both	1998	Un	I	Un
Jornada Experimental Range	Dona Ana	Rural	2000	6	Un	Un
Hawks Aloft Inc.	Taos	Rural	2000	2	Un	Un
	San Juan	Rural	2000	12	Un	Un

^a S = stable, I = increasing, D = decreasing, Un = unknown.

^b F = food, OP = owl persecution, PC = precipitation, H = good habitat, LH = loss of habitat, Un = unknown.

course, in Finley's survey, a greater proportion of the counties were surveyed than could be done by the BBS, more time was spent searching for owls at each colony, and Burrowing Owls were one of only three species being examined in the Prairie Partners work.

Owl Survey by Questionnaire. Survey results (Table 3) indicated that populations in three of the 14 areas (21%) are stable or increasing, three (21%) are decreasing, and eight (57%) are unknown (White Sands Missile Range reported for the same site in Dona Ana County in two different years). Stable and increasing populations were reported to have food and good habitat. Declining populations were thought to suffer from loss of habitat.

The Bureau of Land Management in Roswell reported for seven counties in east-central New Mexico where there are both urban and rural populations of owls. Rural populations have remained stable, while the urban populations appear to have increased near the city of Roswell. The agency felt that increased precipitation had resulted in increased seed supplies for rodents, which were responsible for the apparently stable to increasing owl populations. Even in that area, however, loss of burrows due to control of prairie dogs may have influenced Burrowing Owl populations.

White Sands Missile Range (Fig. 1) reported few owls given the size of the range (about 10 000 km²). On an isolated site of several ha one pair

and their two young were found in 1998. Only three other owls were reported from casual sightings on the missile range.

In the eight areas where owl numbers are listed as 'unknown,' no surveys or counts had been conducted, but biologists had reported casual observations in the areas and had formed impressions about whether or not there were changes in the populations.

North American Breeding Bird Survey. The state has 80 routes that were surveyed at least once during the 33-yr period of analysis. A mean of 28.4 routes (SD = 18.8, range = 8–62) were completed each year, and a mean of 18.3 (SD = 13.9, range = 3–66) Burrowing Owls were counted each year.

A steady decline in mean number of owls per route occurred from 1968–72 (range = 10–12 routes/yr), followed by 12 yr of oscillating numbers (1972–84, range = 8–28 routes/yr; Fig. 2). From 1984–86 there was a large increase. However, in 1984 there were only eight routes surveyed and three owls observed, in 1985 eight routes and 11 owls, and in 1986 eight routes and 13 owls. The 1984–86 increase, then, must be interpreted with caution because so few routes were surveyed. However, between 1987–2000, the number of routes surveyed each year was ≥ 28 (mean number of routes/yr = 46.2, SD = 14.4, range = 28–62 routes/yr, $N = 14$ yr). Therefore, surveys during the years 1987–2000 should reflect Burrowing Owl numbers more accurately. It is in these years that

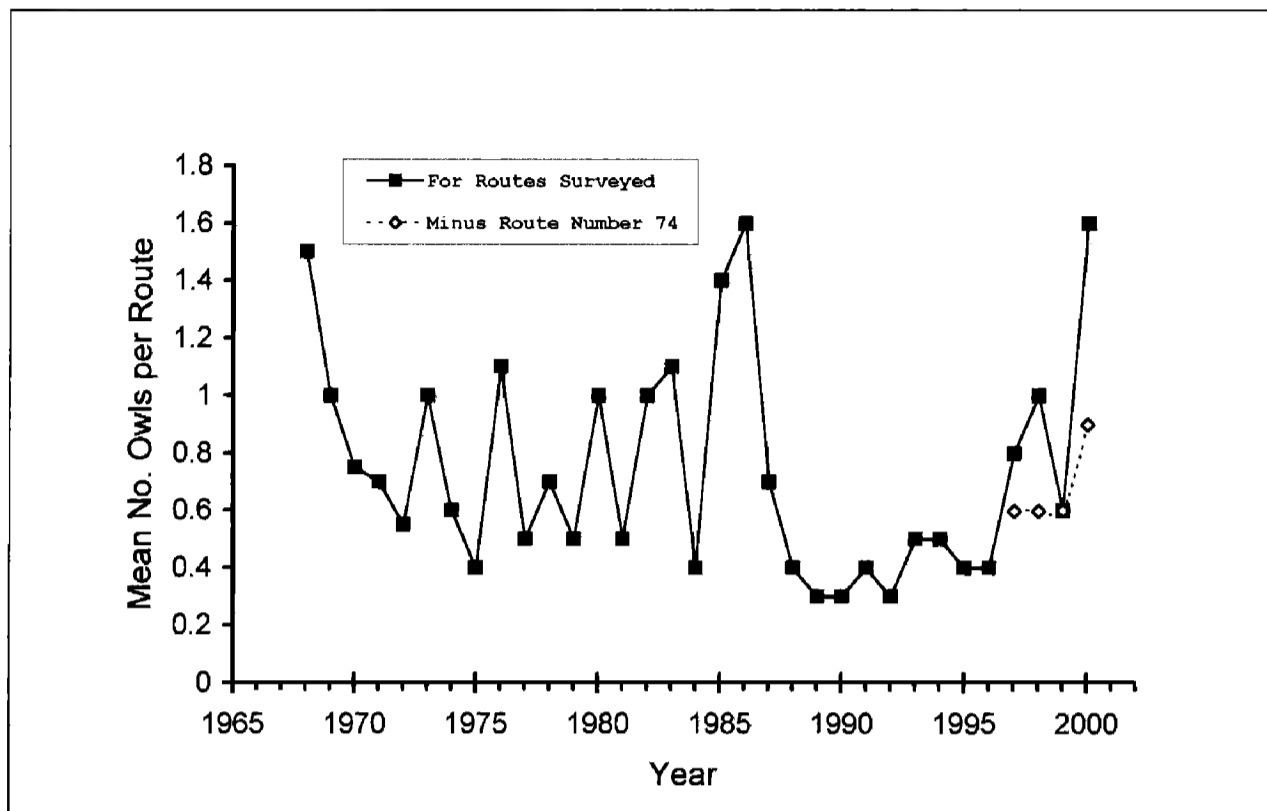


Figure 2. The mean number of Burrowing Owls per route in New Mexico, 1968–2000. Data from the North American Breeding Bird Survey.

owl numbers reached their lowest mean/route. Beginning in 1997, owl numbers showed an upward trend, culminating in 2000 with the highest (equal to 1986) mean number of owls/route. In 1997, route 74, a route that was first surveyed in 1992, reported an owl count that was 27% of that year's count; its 1998 count was 38% of the total; 1999's was 15%; and 2000's was 21%. Excluding counts from route 74, owl numbers leveled off from 1997–99, and then there was a modest increase in 2000 (Fig. 2). The factors responsible for route 74's high numbers from 1997–2000 compared to all other routes during those years are unknown.

Using the BBS results, we were able to identify specific areas (counties, locations, and routes) with the most Burrowing Owls. Six of the 10 counties with the highest numbers of owls are in the eastern part of the state, one is in the southwest, one in the northwest, one south-central, and one central (Table 4). All of these are in ecozones known to be used by Burrowing Owls (Fig. 1).

The central county, Valencia, with the highest total count, is south of Albuquerque in the Rio Grande valley. Irrigation ditches distribute water from the river to farmland. Plains-mesa sand scrub and desert grassland exist east and west of the val-

Table 4. Rank order of the ten highest county totals for Burrowing Owls (1968–2000), based on North American Breeding Bird Survey data.

COUNTY	LOCATION	BBS ROUTE NUMBERS	TOTAL OWLS REPORTED
Valencia	Central	15	89
Roosevelt	East-central	18, 74	83
Union	Northeast	6, 56, 62	50
Lea	Southeast	24, 30, 80, 130	40
DeBaca	East-central	17	39
Colfax	Northeast	5	38
Chaves	East-central/Southeast	23, 73	36
Luna	Southwest	25, 82	26
San Juan	Northwest	51	19
Dona Ana	South-central	77	12

ley farmland. BBS route 15 extends east-west across all three ecozones. It was surveyed each year from 1968–79; the 57 owls counted in this interval represent 42% of all owls reported in the state for those 12 yr. The route continued to be surveyed each year through 1997. Only three owls (out of 201 for the state), however, were reported in the 10 yr from 1988–97. Thus, a regularly-sampled route showed a marked decline beginning in 1988.

Similarly, route 6 in Union County reported stable owl numbers through 1986 and then no owls after 1991. Route 25 in Luna County had low owl numbers until an increase from 1983–91, but thereafter no owls were found.

In contrast, other routes (17, 18, 23) were sampled each year and had low to moderate numbers of owls throughout, without any striking changes. Routes 5 and 74 had no to low counts until 1992–93, then increased counts through to 2000. The remaining routes in Table 4 (24, 30, 51, 56, 62, 73, 77, 80, 82, 130) were often not surveyed until 1991–92 and then had low to moderate owl counts through 2000.

Burrowing Owls at Prairie Dog Re-establishment Sites. At the Ladder Ranch, Burrowing Owls had not been previously seen at the re-establishment sites and very few were reported anywhere on the ranch. By 1998, seven owl pairs were observed (J. Truett pers. comm.). In 2000, the two smaller prairie dog colonies ($N = 11$ adult prairie dogs each) each had two Burrowing Owl pairs, while the larger colony ($N = 44$ adult prairie dogs) had no Burrowing Owls (M. Wolf pers. comm.).

At the Armendaris Ranch in 2000, 24 Burrowing Owl pairs were found, 15 of which produced 53 fledglings (D. Berardelli pers. comm.).

Some Burrowing Owls at the Gray Ranch have been seen in the prairie dog colonies, but they also readily use kangaroo rat dens. Owls here have been termed “abundant,” with no apparent declines or increases over the last 10 yr (B. Brown pers. comm.).

OTHER REPORTS AND SIGHTINGS

At the Jornada Experimental Range near Las Cruces, three pairs of Burrowing Owls were found in 2000 (D. Berardelli pers. comm.). There are no prairie dog colonies at this site, but there are rock squirrels and other mammals that provide burrows.

Hawks Aloft Inc. (unpubl. data) surveyed three BHP World Minerals mines in northern New Mex-

ico for breeding raptors. One Burrowing Owl pair raised four young at the McKinley Mine, a surface coal mine on the Navajo Nation in northwestern New Mexico. Two other mines on the Navajo Nation were surveyed, both of which encompassed grassland areas with active prairie dog colonies. At the 3200 ha San Juan Mine, two Burrowing Owl pairs fledged a total of 10 young, but the fledging status of two other occupied burrows was unknown. The 13 000 ha Navajo Mine had four owl pairs that fledged a total of 12 young, but the number of fledglings was unknown at five other occupied burrows. Hawks Aloft Inc. also found two adults on a prairie dog colony at the Rio Grande Gorge in Taos County, north-central New Mexico.

To extend the study started at New Mexico State University, D. Berardelli (pers. comm.) is evaluating the nesting success of Burrowing Owls in urban areas of Las Cruces and Dona Ana County and in a native environment, the Armendaris Ranch. Berardelli and Arrowood found 35 pairs in Las Cruces in 2000; 24 pairs occurred at the Armendaris Ranch in 2000.

DISCUSSION

The continuing loss of prairie dogs is probably one of the most important factors influencing Burrowing Owl numbers in New Mexico. Around the turn of the century, Bailey (1932:123–124) observed extensive prairie dog colonies in southwestern New Mexico, particularly in Grant County. Bailey estimated that a third of Grant County was covered by prairie dog colonies, and using an estimate of 25 dogs/ha, he extrapolated that Grant County had 6.4 million prairie dogs. Such populations were almost certainly present in other parts of the state as well, particularly on the eastern plains. Burrowing Owls are currently finding and nesting in colonies where prairie dogs have been re-established, demonstrating the importance of these colonial sciurids for the owls. Rock squirrel colonies may substitute in part for prairie dog colonies, maintaining Burrowing Owls in some areas. Because Burrowing Owls and prairie dogs have shared an evolutionary history as a consequence of living together, it is not yet clear how the owls will fare in their association with rock squirrels.

Loss of habitat and burrows caused by increased development (i.e., conversion of arid lands to farmland, farmland to housing developments and commercial construction, the expansion of oil fields, etc.), must also affect Burrowing Owl pop-

ulations. Decreased habitat quality and availability are, for example, reported to be major factors in the decline of Burrowing Owls in Canada (Zarn 1974, Wedgwood 1978, Haug and Oliphant 1990) and in California (McCaskie et al. 1979, Garrett and Dunn 1981). We receive numerous calls about owls in areas where construction is planned, but these represent a small proportion of the owls that are affected by development leading to loss of their burrows and offspring. However, Burrowing Owls are very adaptable; some have tolerated high levels of disturbance around their burrows (pers. observ.). Although relocations of nesting pairs have not been successful (C. Finley, C. Blood, P. Arrowood pers. observ.), pairs have sometimes been enticed away from construction areas by providing artificial burrows nearby (i.e., passive relocation; P. Arrowood, C. Blood pers. observ.). We have alerted city officials, planners, and landowners about the presence of owls so that nest burrows are not disturbed during the breeding season; we then worked with developers to provide owls other burrow sites to occupy once breeding was completed. There has been no overall loss of habitat or increase in disturbance at NMSU or Kirtland Air Force Base, yet owl numbers have declined in recent years at those sites.

The state of Chihuahua in Mexico has suffered severe droughts in recent years, forcing many residents to abandon their homes and farms. Although we do not know where the migrating owls of New Mexico spend the winter, Chihuahua is a candidate site for at least some of them. Thus, the drought conditions may affect winter survival and the number of owls that return to New Mexico. P. Arrowood (unpubl. data) has correlated the arrival of Burrowing Owls in Las Cruces with strong weather fronts coming out of the south, in the direction of Chihuahua. In Las Cruces, weather fronts coming from the west, southwest or southeast have not been associated with the arrival of owls. Owls that nest on the eastern plains may be overwintering in southern and/or western Texas where severe drought conditions have also occurred in some areas in recent years.

We know from our studies at NMSU, and at Holloman and Kirtland air force bases, that owls banded in a given year sometimes return the next year, and others go away for several years and then return. Some owls do not migrate but, instead, overwinter at the burrow they occupied in the previous summer. More males than females overwinter at

NMSU (P. Arrowood unpubl. data). Additionally, observers at Holloman and Kirtland air force bases have not recorded any of the owls that were banded at NMSU, and vice versa. At all three sites, unbanded owls appear each spring. We do not know the movement patterns of the owls or how much site fidelity exists. With most of the urban and rural populations of owls in the Las Cruces area unbanded, many new owls could appear on the NMSU campus after having moved as little as 1–2 km. If the owls do display strong site fidelity and their site becomes uninhabitable, the stress of finding a new area could both delay breeding and affect the number of offspring they are able to raise.

We have tried to pull together as many sources of information about Burrowing Owl numbers in New Mexico as we could locate. We have emphasized trends as opposed to absolute numbers. Based on a previous agency questionnaire, James and Espie (1997) reported New Mexico's population as stable, with 1000–10 000 Burrowing Owls, but those estimates were not derived from counts. The level of concern about the owl at this time is moderate but reflects the necessity to monitor the owls closely. This moderate concern is reinforced by the data we have summarized: some areas have experienced declines and some increases. Owls are moving into re-established colonies of prairie dogs in central New Mexico. Artificial burrows are being put in place where natural burrows have been lost and owls are using the artificial burrows. However, we do not know how many prairie dogs are being lost throughout the state, nor what conditions the owls experience where they overwinter.

ACKNOWLEDGMENTS

We would like to thank all those who took the time to participate in our questionnaire. Their efforts will help identify the future needs of the Burrowing Owl so that proper management goals can be established. We are also grateful to the scores of participants in the North American Breeding Bird Survey. Brad McKown and Ken Boykin provided Figure 1. Roy Arrowood and Ralph Campbell provided assistance. The Agricultural Experiment Station at NMSU provided further assistance. P.C. James, M. Rowe, T.I. Wellicome, and an anonymous reviewer provided valuable comments on the manuscript.

LITERATURE CITED

- BAILEY, V. 1932. Mammals of New Mexico. *N. Am. Fauna* 53:1–412.
- BOTELHO, E.S. 1996. Behavioral ecology and parental care of breeding western Burrowing Owls (*Speotyto cunicularia hypugaea*) in southern New Mexico, U.S.A.

- Ph.D. dissertation, New Mexico State Univ., Las Cruces, NM U.S.A.
- AND P.C. ARROWOOD. 1996. Nesting success of western Burrowing Owls in natural and human-altered environments. Pages 63–68 in D. Bird, D. Varland, and J. Negro [EDS.], *Raptors in human landscapes*. Academic Press Ltd., London, U.K.
- AND ———. 1998. The effect of burrow site use on the reproductive success of a partially migratory population of western Burrowing Owls (*Speotyto cunicularia hypugaea*). *J. Raptor Res.* 32:233–240.
- DICK-PEDDIE, W.A. 1993. New Mexico vegetation: past, present, and future. Univ. New Mexico Press, Albuquerque, NM U.S.A.
- FINDLEY, J.S., A.H. HARRIS, D.E. WILSON, AND C. JONES. 1975. *Mammals of New Mexico*. Univ. New Mexico Press, Albuquerque, NM U.S.A.
- GARRETT, K. AND J. DUNN. 1981. *Birds of Southern California*. Los Angeles Audubon Soc., Los Angeles, CA U.S.A.
- HAUG, E.A. AND L.W. OLIPHANT. 1990. Movements, activity patterns and habitat use of Burrowing Owls in Saskatchewan. *J. Wildl. Manage.* 54:27–35.
- , B.A. MILLSAP, AND M.S. MARTELL. 1993. Burrowing Owl (*Speotyto cunicularia*). In A. Poole and F. Gill [EDS.], *The birds of North America*, No. 61. The Academy of Natural Sciences, Philadelphia, PA and American Ornithologists' Union, Washington, DC U.S.A.
- JAMES, P.C. AND R.H.M. ESPIE. 1997. Current status of the Burrowing Owl in North America: an agency survey Pages 3–5 in J.L. Lincer and K. Steenhof [EDS.], *The Burrowing Owl, its biology and management including the proceedings of the first international Burrowing Owl symposium*. *J. Raptor Res. Report* 9.
- MCCASKIE, G., P. DEBENEDICTUS, R. ERICKSON, AND J. MORLAN. 1979. *Birds of Northern California*. Golden Gate Audubon Soc., Berkeley, CA U.S.A.
- SAUER, J.R., J.E. HINES, AND J. FALLON. 2001. *The North American breeding bird survey, results and analysis 1966–2000*. Version 2001.2, USGS, Patuxent Wildlife Research Center, Laurel, MD U.S.A.
- THOMPSON, B.C., D.F. MILLER, T.A. DOUMITT, T.R. JACOBSON, AND M.L. MUNSON-MCGEE. 1996. An ecological framework for monitoring sustainable management of wildlife: a New Mexico furbearer example. *National Biol. Serv. Info. and Tech. Rep.* 5, Las Cruces, NM U.S.A.
- VERCAUTEREN, T.L., S.W. GILLIHAN, AND S.W. HUTCHINGS. 2001. Distribution of Burrowing Owls on public and private lands in Colorado. *J. Raptor Res.* 35:357–361.
- WEDGWOOD, J.A. 1978. The status of the Burrowing Owl *Speotyto cunicularia* in Canada. *Committee on the Status of Endangered Wildlife in Canada*, Ottawa, ON Canada.
- ZARN, M. 1974. Burrowing Owl, *Speotyto cunicularia hypugaea*. Report 11. *Habitat Management Series for unique or endangered species*. Bureau Land Manage., Denver, CO U.S.A.